# *On the Generation of a Luminous Glow in an Exhausted Receiver moving near an Electrostatic Field, and the Action of a Magnetic Field on the Glow so produced.*

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1. In 1896* I found that bulbs exhausted as a Crookes radiometer, when bombarded by a discharge from a Tesla inductor, produced X-rays, and X-ray photographs of the hand were then made, using only exhausted bulbs having no terminals. The bulbs had the following dimensions: 5 cm. diameter, stem 12 cm. long, 0·4 cm. diameter.

I had from time to time noticed that when any of the exhausted bulbs were rubbed on the palm of the hand, they became luminous for a brief period while they were being rubbed.

In December, 1907, I returned to the subject, using these same exhausted bulbs in connection with certain apparatus in which plates of sulphur were employed as insulators. Happening to move an exhausted bulb near a sulphur plate in the dark, I noticed that it glowed for an instant. It then became evident that an exhausted vessel, moving in an electrostatic field, itself became electrified and consequently glowed.

2. An exhausted bulb was mounted by its stem in a hollow mandrel running in a bearing; it was rotated by means of a pulley, driven by a cord connecting it to a small motor. Under the bulb a plate of sulphur was placed in the horizontal plane at distances varying between 1 cm. and 13 cm. The glow was apparent at 13 cm.

3. The bulb was rotated about 20 times per second. The sulphur was rubbed on the hand before being placed below the bulb. When the bulb was rotated it became instantly filled with a luminous glow, with a patch of greenish light brighter than the rest of the glow situated about 90° from the vertical. When rotation was reversed, the patch appeared on the opposite side of the bulb, also about 90° from the vertical.

4. In the next experiment the statically charged body placed under the rotating bulb consisted of a brass disc supported on an insulated stem. The disc was connected to an electroscope, and charged to 1200 volts. The bulb was rotated as before; the charged disc remained charged during the

* 'Nature,' vol. 54, p. 594.

experiment, which lasted about six minutes, and showed no signs of being discharged.

5. An electrostatic field of opposite sign was maintained on two opposite sides of the bulb; the glow throughout the bulb was considerably increased, but when two similarly charged discs were placed at equal distances on the opposite sides of the bulb, the glow ceased, and when one was charged to a higher potential than the other the glow again appeared, apparently due to the difference of charge of the two discs.

6. Touching the rotating bulb lightly with a finger did not affect the appearance of the glow in any perceptible way.

7. The bulb was rotated in the electrostatic field due to the disc of sulphur which had been rubbed on the hand, placed above the bulb in the horizontal plane, and below the bulb an insulated metal disc was placed connected to the electroscope; no transfer of electricity to the disc was indicated.

8. A disc of sulphur (10 cm. diameter) was mounted on a face plate of wood rotated by a mandrel (running in ball bearings) as in a lathe; the disc of sulphur was rubbed so as to establish an electrostatic field. When it was rotated near an exhausted bulb or exhausted tube, no glow was produced.

9. The sulphur disc, while rotating if used as the inductor of an electrophorus, acted in exactly the same manner as if at rest. The disc was rotated from one revolution per second up to 20 revolutions per second.

10. Five bulbs were prepared and rotated in an electrostatic field of constant strength. Some were exhausted to the same condition of vacuum as the radiometer of Crookes; some to the condition of a Röntgen X-ray tube. The glow in those exhausted to the Röntgen vacuum was far brighter than that in those not so exhausted.

11. The electroscope used to measure the P.D. of the charges was designed by Professor Townsend, F.R.S., of Oxford; it is calibrated so that each division of the scale indicates 100 volts. It is capable of keeping its charge for many days.*

12. The experiments show that when an exhausted glass vessel is rotated in an electrostatic field an electrical glow is created, the intensity of which varies in some way with the velocity of rotation, while the position of maximum glow changes its position with the direction of rotation.

13. Since the bulbs were exhausted by means of a mercury pump (used by the manufacturer of Röntgen tubes), there may possibly be a very thin coating of mercury on the inner wall of the bulbs. An exceedingly minute

* 'Nature,' vol. 77, p. 149, "Sulphur as an Insulator," by F. J. J.-S.

coating of mercury on vessels exhausted by the mercury pump has recently been suggested as the cause of the change of conductivity of selenium when placed in a vessel exhausted by a mercury pump.

*The Action of a Magnetic Field on the Radiant Glow in an Exhausted Vessel rotated in an Electrostatic Field.*

Considering the conditions subject to which the glow is generated it seemed probable that it would be unidirectional in its nature, and would therefore be acted on by a magnetic field. This was found to be the case.

In preliminary experiments on this point a permanent magnet was employed, but, for convenience of reversal of the poles, it was replaced by an electromagnet taken from a Morse instrument by Siemens and Halske. The poles of the electromagnet were placed within 0·5 cm. of the bulb, in several different positions.

The conditions of the experiment were varied in six ways :—

(1) The static charge was either positive or negative.

(2) The rotation of the bulb was either in the clock-hands sense or the reverse.

(3) The magnetic pole, in different experiments, was north or south.

Both a horseshoe electromagnet and a long cylindrical electromagnet were used in the different experiments : the current of electricity used to energise the electromagnet was supplied from accumulators, a reversing key being placed in the circuit.

Effect of two magnetic poles on the glow. (Fig. 1.) D, disc giving the electrostatic field, charged inductively by means of a disc of sulphur rubbed on the dry hand.

Rotation of the bulb, clock-hands sense, to an eye at A. Revolutions 20 per second.

No current on electromagnet. A greenish-blue glow filled the bulb.

Electromagnet on, the glow took the form of an equatorial bright band, brightest between the poles of the electromagnet, where its shape was modified as shown.

Fig. 2.—Bulb exposed to south pole. Charge on D as in Fig. 1. Rotation, clock-hands sense. The glow filled a hemisphere of the bulb P with an equatorial band a little more brilliant than the rest of the hemisphere.

Fig. 3.—Bulb exposed to south pole. Rotation contrary to clock-hands. The glow filled a hemisphere of the bulb Q with equatorial band a little more brilliant than the rest of the hemisphere.

If, while the charge on D and the rotation of the bulb are kept the same,

* 'Nature,' vol. 77, p. 222.

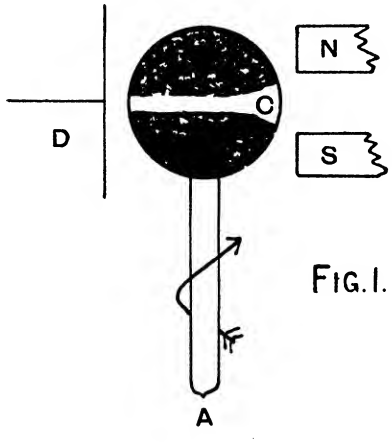


FIG. 1.

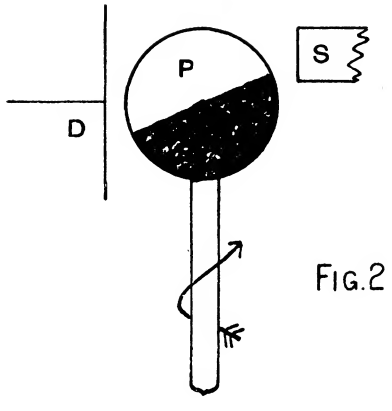


FIG. 2.

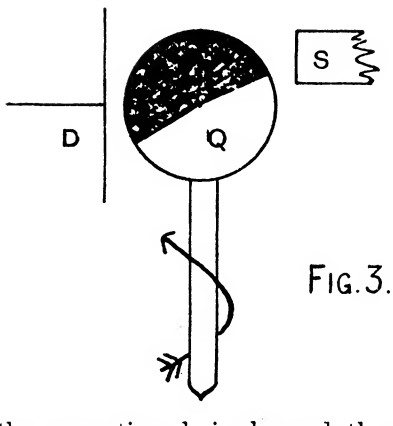


FIG. 3.

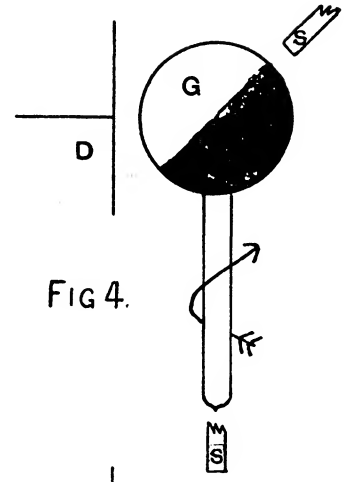


FIG 4.

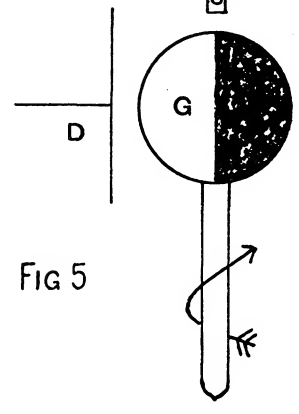


FIG 5

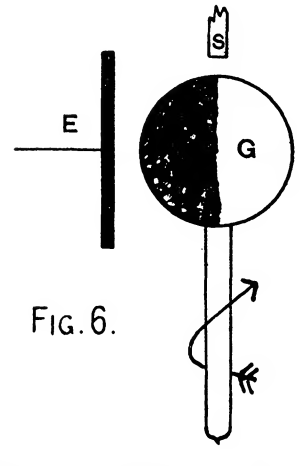


FIG. 6.

the magnetic pole is changed, the glow phenomenon is reversed. Also when the charge on D and the magnetic pole are kept the same, but the sense of rotation is reversed, the glow phenomenon is reversed.

14. The experiments in which one pole of the horseshoe magnet was employed were all repeated with an electromagnet of cylindrical form, so that only one pole was near the bulb.

Fig. 4.—The electrostatic field was maintained by a brass disc D charged by induction from rubbed sulphur. The views of the apparatus and phenomena are as seen by an eye above looking vertically down on them.

The axis of the electromagnet was placed in the horizontal plane through the centre of the bulb, at 45° from the axis of rotation of the bulb. Glow in hemisphere G. Reversal of the magnetic pole deflected the glow to the opposite hemisphere. Rotation, clock-hands sense.

Fig. 5.—The axis of the electromagnet was in the axis of rotation of the bulb. Magnetic pole south. Glow G in hemisphere nearest to the disc. This was exactly reversed when the north pole was used.

Fig. 6.—E, a sulphur disc which had been rubbed, was used to maintain the electrostatic field. Glow at G, away from sulphur disc. Magnet pole south. The glow illuminated the opposite hemisphere when the north pole was presented to the bulb.

In each case the glow is most brilliant in a region the mid-point of which is about 90° from the axis of the electromagnet.

Shifting the pole of the electromagnet shifts the equatorial plane separating the dark and glow-filled hemispheres.

15. A summary of the relationship which exists between the direction of rotation of the bulb, the charge of the inductor D, and the name of the magnetic pole, may be stated thus.

When the rotation of the bulb is in the clock-hands sense, to an eye looking along XO, the charge on the inductor positive, the magnet pole south, the deflection of the glow is to the right of the south pole as shown in fig. 7. B, bulb with axis of stem lying in OX, magnet pole south, P*p* direction of deflection of glow matter. If any one of the conditions, namely, sense of rotation, sign of charge on the inductor or magnet pole, be reversed, while the other two remain unchanged, the deflection of the glow is reversed.

16. Experiments have been made and are now being continued with a view to discover whether the glow will affect a photographic plate. When placed in a light-tight case, only very slight traces of this action have as yet been found by me.

17. In order that the phenomena might be seen under any climatic conditions, the whole of the inductional apparatus was enclosed in a box having a glass lid, fitted with an air-tight rubber joint, the interior being kept dry with sulphuric acid.

The discs were charged from the outside of the box by means of conductors

led into it through sulphur plugs. The phenomena could then be observed for any required time.

18. Many forms of exhausted vessels were employed; of these an exhausted ring (10 cm. diameter, made from tube having an internal bore of 1 cm.)

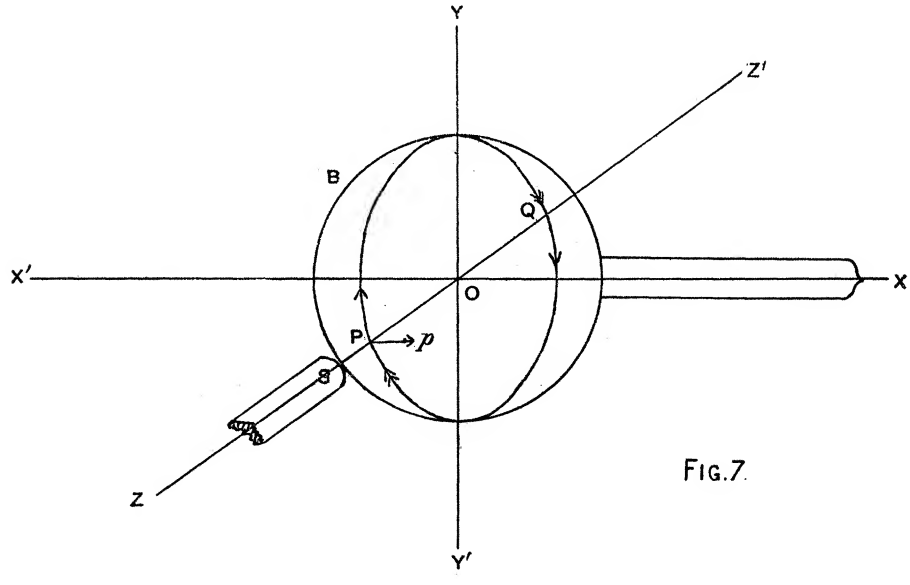


FIG. 7.

revolving about a diameter, in an electrostatic field, gives a good and beautiful glow.

19. In conclusion, I wish to offer my best thanks to the President of the Royal Society for comments on the phenomena described in this paper.

The diagrams for the paper were prepared by Mr. E. J. Jervis-Smith, R.F.A., who has assisted me in carrying out the experiments.